BIO1140 Introduction to Cell Biology

Professor: Dr. Caroline Petit-Turcotte

Midterm Exam 2 – Version DD: Friday March 20th, 2015

PLEASE DO NOT OPEN EXAMS UNTIL YOU ARE INSTRUCTED TO DO SO.
MAKE SURE YOU HAVE A COMPLETE EXAM PACKAGE – 1 QUESTIONNAIRE (13 PAGES) AND 1 SCANTRON SHEET

General Instructions:

1. This exam is worth 15% of your final mark.
2. You will have 1hour and 15 minutes (75 minutes) to write the exam.
3. Write your name and student number on the first page, and write your student number in the space provided on all subsequent pages.
4. You should only have writing material and this exam on your desk, nothing else.
5. When you have finished, raise your hand and a TA will come pick up your exam. Please remain in your seat during the last 15 minutes.

Part A Instructions (20 marks): Multiple Choice.

1. Use pencil. Indicate only one answer for each of the 20 multiple choice questions, directly on the computer scan sheet (Scantron). *Do not attempt to change an answer if you use ink*. This will be recorded as 'incorrect'. You will need a new Scantron sheet.
2. Follow instructions on the computer Scantron sheet. – Make sure you include your student name and number, and the exam version; BIO1140DD.
3. The answer on your Scantron is the answer that will be marked. Make sure you fill in your answers on the Scantron before the time for the exam is up. You will NOT be given extra time to do so. Answers not appearing on the Scantron will not be marked

Parts B-D Instructions (52 marks): Long Answers.

1. You may write in ink or in pencil. If you choose to answer in pencil, a marking review may not be awarded and is at the discretion of the professor or course coordinator.
2. Please provide a written answer for all questions within the space provided. You may use point form as long as these points are clear and complete.
3. Marks will not be given for irrelevant or illegible writing. Organize your thoughts carefully.
4. You may use a diagram as an aid, but a diagram alone will not constitute a complete answer.

Good luck!

Student Name: _____CORRECTION KEY_____

Student Number: _____

Version DD Student number: _____

Section A – Multiple Choice Questions (20 questions – 1 mark each)

Please transfer your answers, in pencil, to the Scantron sheet provided – we will not transfer answers

1. Which of the following choices is able to translocate phosphatidylserine to the outer leaflet of the plasma membrane to trigger phagocytosis?

a) F-type ATPase

b) Caspase

c) Scramblase

d) Calcium

2. A cell releases a chemical messenger, and after a short time spent in the extracellular space, this messenger binds to a receptor on the surface of that same cell. Which communication path is this?

a) Paracrine

b) Endocrine

c) Exocrine

d) Autocrine

3. Which one of the following cellular consequences is not related to caspases?

a) Initiate DNA fragmentation

b) Cytoplasm and cell size shrinking

c) Loss of ATPase activity

d) Disrupt cell adhesion and initiate blebbing

4. If you were to look at cells undergoing cell death to compare necrosis and apoptosis, which of these observations would you expect to see in necrotic cells:

a) Decaying mitochondria

b) Rearrangement of the cristae

c) Loss of adhesion

d) Condensation of the nucleus

5. Cellular communication can be organized in three key steps. Which of these statements is NOT relevant to one of them?

a) The signal is relayed to effectors in the cell

b) A ligand is received by the target cell

c) The number of mitochondria must increase

d) The target cell initiates changes to address the signal

6. Which one of these chemical messengers is able to interact with ligand-gated ion channels and G-protein coupled receptors?

a) Adrenalin

b) Nitric oxide (NO)

c) Insulin

d) Acetylcholine

7. What is the major difference between signal transduction cascades using intracellular receptors when compared to transmembrane receptors?

a) The ligand and receptor are both part of the transduction

b) The ligand is irrelevant

c) The receptor does not have a ligand binding domain

d) The cascade does not lead to any changes in the cell

8. Which of these types of proteins would be the ideal candidate to act as a ligand-gated ion channel?

a) Monomeric integral protein

b) Prenyl-anchored protein subunits

c) Calcium binding protein

d) Multiple protein subunits within the membrane

9. Which of these is not an efficient mechanism to end cellular communication?

a) Activation of a gene transcription factor

b) Degradation of the ligand

c) Inactivation of the receptor by phosphorylation

d) Endocytosis of the receptor-ligand complex

10. When mitochondria become damaged, what must first be expressed on their surface to trigger their transfer to the lysosome?

a) Parkin

b) Ubiquitin

c) Pink

d) None of the above

11. What is the coordination of cellular pathways aimed at avoiding futile and contradictory cycles called?

a) Agonism

b) Inhibition

c) Synergism

d) Antagonism

12. How did Hershey and Chase demonstrate that DNA is responsible for heredity?

a) By tracking ^{35}S radiolabelled DNA in *E.coli* and in progeny phages

b) By using virulent strains of *Streptococcus pneumonia* in mice

c) By tracking ^{32}P radiolabelled DNA in *E.coli* and in progeny phages

d) By using non virulent strains of *Streptococcus pneumonia* in mice

e) None of the above

13. Within DNA, nucleotides arrange themselves in a specific pairing. What is the proper pairing and why is it the only possible arrangement?

a) Purine and Pyrimidine; because the diameter of the helix must be greater than 2 nm

b) Purine and Pyrimidine; because the diameter of the helix must be approximately 2 nm

c) Purine with Purine; because this is the only conformation that leads to a helix

d) Pyrimidine with Pyrimidine; because this is the only conformation that leads to a helix

e) None of the above

14. During elongation, each additional nucleotide is added to the strand….?

a) … by joining its phosphate group to the 3rd C of the deoxyribose

b) … by joining its phosphate group to the 5th C of the deoxyribose

c) … by joining the nitrogenous base to the 3rd C of the deoxyribose

d) … by joining the nitrogenous base to the 5th C of the deoxyribose

e) None of the above

15. The flow of genetic information can only occur in a single direction according to the Central dogma of molecular biology. Therefore, which of these statements is accurate?

a) Translation –> Replication –> Transcription

b) Transcription –> Replication –> Translation

c) Translation –> Transcription –> Replication

d) Replication –> Transcription –> Translation

16. Watson and Crick had a pretty good idea as to how DNA was able to replicate itself, but lacked the tools to prove it. A few years later, who was able to design an experiment to prove the replication model?

a) Hershey and Chase

b) Meselson and Stahl

c) Griffith and Frederick

d) Avery and Franklin

17. Which of these statements describes the role of the primase?

a) Assemble a short sequence of RNA 5’ to 3’ to recruit the DNA polymerase

b) Assemble a short sequence of RNA 3’ to 5’ to recruit the DNA polymerase

c) Assemble a short sequence of DNA 5’ to 3’ to recruit the DNA polymerase

d) Assemble a short sequence of DNA 3’ to 5’ to recruit the DNA polymerase

e) None of the above

18. G-proteins are actually three protein subunits. Which of the three is/are NOT directly involved in the PIP2 pathway?

a) The beta (β) subunit

b) The gamma (γ) subunit

c) The alpha (α) subunit

d) Both a and b are correct

19. How can incorrectly mismatched nucleotides be corrected?

a) Nucleotide excision repair

b) Telomeric extension

c) Restriction enzymes

d) They cannot be corrected

20. What is the most powerful technique to produce a large number of copies of a target DNA sequence?

a) A Xerox machine

b) Cloning

c) Polymerase chain reaction

d) X-ray crystallography

You have completed section A; please continue to the next page for sections B to D.

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Section B – General knowledge (1 mark each – Total 7 marks)

Please answer within the provided space – make sure your answer is clear and legible

1. Which type of cell death involves cellular lysis?

_____Necrosis_____

2. Define adaptor proteins and give an example:

Protein that can bind to the tyrosine kinase receptors using their SH2 domains and to effector proteins by their SH3 domains (0.5 marks)

If there is a sense of acting as a bridge between receptor and effector (or synonyms), without mention of SH2/SH3 BUT with the need for a specific conformation, accept it. Receptor binding to second messenger is NOT acceptable.

Examples: Grb2 / Sos (if others provided and accurate, accept, for example, SHC, Irs, Src, Jak/Stat, Akt) (0.5 marks)

3. What are lipid rafts and why are they relevant for cellular signalling?

They are microdomains (accept small areas or regions) of the membrane that are rich in sphingolipids and cholesterol. (0.5 marks – both sphingolipids and cholesterol MUST be present for marks)

Accommodate long or large transmembrane domains/proteins/receptors (0.5 marks)

4. Define a telomere?

A region of repeated non-coding nucleotides at the end of linear DNA (chromatids / chromosomes) that protects the coding regions from shortening during replication (and prevents them from attaching to each other).

5. Once the helicase has unwound the DNA helix, what allows it to remain as a single-strand?

_single strand binding proteins_____

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6. Name 2 of the 6 ways to end a signal transduction cascade: (2 marks)

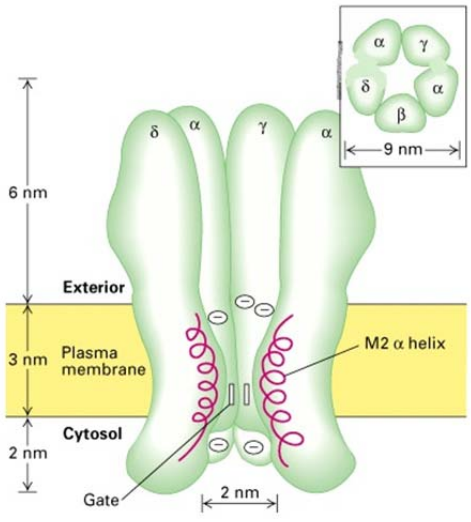
Name 2 of these 6 possible answers:

- Ligand removed by neighbouring/distant tissue
- Ligand/receptor removed by endocytosis
- Ligand degraded by extracellular enzymes
- Ligand taken up by adjacent cells
- Inactivation of signal transduction pathway
- Inactivation of the receptor

Section C – Fill in the blanks / Associate (1 mark each – total of 37 marks)

1. Complete the following sentences using the most appropriate term: (10 marks)

a. Using the following figure, fill in the blanks:



In order to become activated, this type of receptor, a __ligand____ ___gated___ (**2 separate words**) ion channel will have bound its ligand, acetylcholine, on the alpha subunits. This leads to a change in conformation of the receptor, opening the channel. This enables the passage of ions, specifically __Na+ (sodium)___ and _Ca2+ (calcium)__ towards the inside of the cell, and some _K+ (potassium)__ towards the outside of the cell. This leads to a change in the electrochemical gradients which can be used by the cell to conduct certain activities such as; (**give an example**) __muscle contraction, action potential, vesicle exocytosis, etc. any accurate example is accepted____.

b. A chemical substance that fits into a specific binding site on the surface of an integral protein is called a ___ligand_____. This induces a change of ___conformation____ for that protein.

c. DNA replication is accomplished by first unwinding the DNA. The enzyme ___helicase_____ carries out this important task. The addition of nucleotides on the daughter strand is always done at the ____3'___ end.

2. When considering RNA, what are three things that are different from DNA: (3 marks)

a) ____The sugar (ribose and not deoxyribose)_____

b) _____Single strand helix (not double strand)_____

c) ____No Thymine only Uracil_____

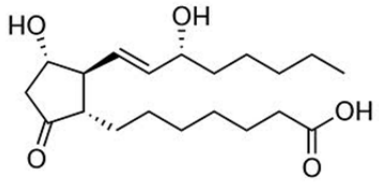
3. Compare the two following receptors by completing the table below. (3 marks)

Criteria	**Intracellular receptor**	**G-protein coupled receptor**
Ligand properties	Hydrophobic or lipophilic Small able to diffuse across membrane	Hydrophilic
Main result of receptor activation (signal transduction mechanism)	Ligand and receptor act as a transcription factor and bind to regulatory elements to change gene transcription	Alpha subunit of G protein is recruited and activated and will in turn activate the amplifier enzyme to produce second messenger
Example of a cellular response obtained	Reduction of insulin transcription as a result of cortisol (any valid example is accepted – steroid response elements on sex hormone production; retinoids, aldosterone etc)	Muscle contraction or relaxation Blood vessel dilation or constriction Glycogenolysis Etc

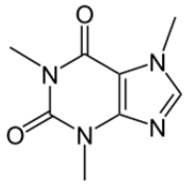
4. Associate the following molecular structures with the chemical messenger classes (3 marks) :

Chemical messenger classes	Choice of molecular structure
Purine	B
Gas	D
Eicosanoid	A
Amine	F
Peptide	C
Steroid	E

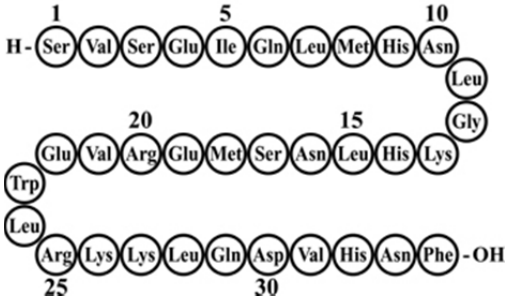
A)



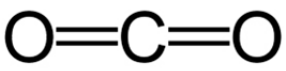
B)



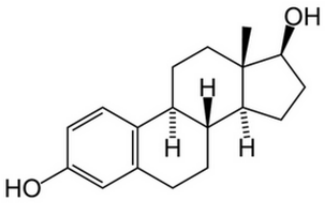
C)



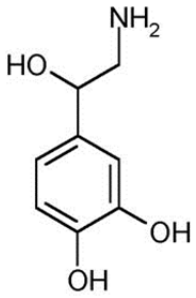
D)



E)



F)



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5. Here is a strand of DNA. You must identify on the strand where replication of the complementary strand would begin, list the steps and enzymes that will carry it out, and provide the sequence of the complementary strand obtained. (5 marks)

5' CGATGTGACGTAGCT 3'

1. Primase places an RNA primer
2. DNA polymerase III (accept 3) and sliding clamp protein recognize double strand portion and begin completing the complementary strand
3. Once complete, DNA polymerase I (accept 1) will replace each RNA nucleotide for a DNA nucleotide
4. DNA ligase (accept ligase) will complete the phosphodiester bond to seal the nick left behind by DNApol.I

Obtained sequence: 3' GCTACACTGCATCGA 5'

6. Explain why DNA replication occurs differently on both strands of DNA. (4 marks)

- Replication takes place from the origin of replication towards the replication fork, on both strands, and in both directions.
- Both parental strands are anti-parallel.
- Elongation (addition of new nucleotides) can only occur at the 3' end of a strand
- Therefore, on each side of the origin, in order to respect these conditions, one parental strand will be
- Replicated continuously (the leading strand) because it is in the proper orientation for elongation, while the
- ther will be replicated discontinuously (lagging strand) because it is not in the proper orientation. This strand will be replicated by portions, 5' to 3' and toward the fork, giving the Okazaki fragments.

If a drawing is used, it should be clearly labelled, with orientation of each strand indicated

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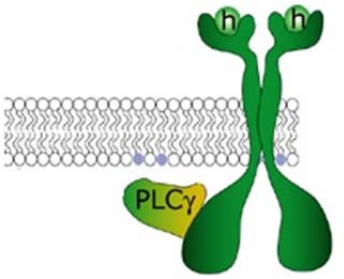
7. Completing the image below, describe the cellular signaling mechanism that will occur for a cell that receives a ligand bringing a growth message, such as EGF. Be sure to describe all the relevant steps of the signalling mechanism required and what the cellular outcome will be. (7 marks)



M.J.W. Adjobo-Hermans & J.Goedhart © 2008

Each following element is worth 1 mark:

This is a receptor tyrosine kinase – so monomers will bind EGF, dimerise and autophosphorylate the Tyrosines in the catalytic domain

Phospholipase C has an SH2 domain and so can directly interact with the phosphorylated tyrosines

It will then become activated and cleave PIP2 (phoshphatidyl inositol bisphosphate) into DAG and IP3 (second messengers).

DAG remains part of the membrane, while IP3 goes on to targets in the cell.

IP3 can activate the IP3-gated calcium channel on the ER membrane, leading to Ca2+ release in the cell.

Calcium can activate PKC, can bind to calcium binding proteins, etc.

The outcome will be to maintain cellular growth

- Note: If more than one pathway described **ONLY** mark the first pathway described

Section D – Long answer questions (10 marks)

1. **Draw** a cell and the relevant organelles, ligands, receptors, etc. to explain the relationship between calcium regulation and muscle contraction. The structure of the muscle's contractile unit is not mandatory; you must focus on the signaling events with respect to calcium in the context of muscles. Make sure your all the elements of your drawing are clearly labelled. You must include a written explanation to complement your drawing. (10 marks)

Drawing of muscle cell : 2 marks (deducted if only an explanation)

Elements required on the drawing / explanation:

- Acetylcholine-gated ion channel in the plasma membrane
- alpha subunit of receptor (2) each bind ACh
- Entry of Na+ and Ca2+ / Exit of small amounts of K+
- Change in electrochemical gradient due to Na+ entry / change in membrane potential (voltage)
- Opening of all voltage gated Na+ channels – greater entry of Na+
- Change in membrane potential propagated along membrane and leads to opening of voltage gated calcium channel on ER membrane (ER must be present and channel labelled)
- Increased intracellular calcium concentration favors calcium binding to troponin which changes conformation
- This pulls on tropomyosin and exposes the myosin binding sites on actin; Muscle contraction is now possible

You have completed the second midterm exam. Home stretch to the final begins!